CHAPTER 10

OVERLAP IN NCEES EXAM OUTLINE CONTENT

The job analyses described in the preceding chapter are designed for use in developing licensing exams. The job analysis for each discipline is carried out in its own unique way, and ISR's effort to use this data to measure overlap across disciplines revealed that these independent approaches create inconsistencies and limitations that prevent the data from being useful for the purpose of measuring overlap. This led to the decision to instead analyze NCEES exam outlines for possible overlap between engineering disciplines.

In theory, the exams are based on what engineers do. However, job tasks for engineers from the same discipline may vary with the job setting. In spite of this variety, the job analysis reports generally provide means and standard deviations for the frequency and criticality of tasks for the sample as a whole rather than separately for a limited number of job settings. Moreover, most job analyses omit unlicensed engineers, which means that, for disciplines with low registration rates, they may not reflect what a majority of engineers do.[1] There is no way to know how well the exam content reflects what licensed and unlicensed engineers really do in a variety of job settings. As a result, conclusions based on the analysis of overlap in exam content may differ from those that might be derived from the analysis of actual overlapping job tasks -- if comparable job analysis data were available for all engineering disciplines.

The analysis described in this chapter is based on the exam specifications maintained by NCEES on their website (www.ncees.org).[2] For each discipline, NCEES provides an outline of the exam content along with the approximate percentage of the exam devoted to each topic. NCEES indicates that "the knowledge areas specified in these outlines are examples of the kinds of knowledge required for the exams, but they are not exclusive or exhaustive categories." Clearly, these outlines were not designed for the type of analysis performed here, but they presented the best available opportunity to examine overlapping knowledge between disciplines. Some of the outlines are very detailed, while others are much more brief. The most detailed, with 92 items, is the outline for the electronics, controls, and communication depth module of the electrical and computer engineering exam. At the other end of the scale, the outline for fire protection engineering contains just 23 items. Because differences in the format of the outlines directly affected the ability of experts reviewing them to make informed comparisons, the level of detail contained in each outline should be considered in interpreting the results presented in this chapter. Another important point, brought up by a number of experts reviewing the exam outlines, is that although disciplines may require similar knowledge, the application of this knowledge may be quite different.

Methodology

Selection of subject matter experts. On the assumption that a discipline's practitioners would be the best judges of what material is subsumed in a subject matter area, ISR selected a sample of experts, representing nine engineering disciplines, to review exam outlines for pairs of disciplines. The disciplines chosen -- civil, electrical, mechanical, chemical, control systems,

[1] The job analyses for civil, chemical, control systems, industrial and mechanical engineering include both licensed and unlicensed engineers.

[2] The material provided to subject matter experts for comparing the exam outlines is included in Appendix H.

fire protection, industrial, manufacturing and nuclear -- represent disciplines with NCEES exams that have the greatest number of registrants in California.

Subject matter experts were chosen from three lists supplied by the Board. The first was a database of Enforcement Technical Experts, consisting of 98 civil engineers, 40 mechanical engineers and 32 electrical engineers. The second was a list of electrical engineers from the Board's Technical Advisory Committee (TAC). And the third was a list of 38 title act Subject Matter Experts (SMEs). All but three of the title act SMEs were contacted. The three who were not contacted specialized in areas that are no longer being examined. A random sample of 15 experts from each discipline was chosen from the lists of civil, mechanical and electrical engineers. The list of experts within each discipline was ordered by license number, providing a rough measure of years of experience as a licensed engineer. Each list was divided into three equal strata and a systematic sample of five experts was selected from each stratum, producing an initial sample of 15 experts from each practice act discipline.

The object was to have roughly equal numbers of experts from each pair of disciplines review the exam outlines. For example, for the comparison between civil and mechanical engineering exam outlines, roughly half should be licensed civil engineers and half should be licensed mechanical engineers. All experts were asked to indicate which disciplines they felt comfortable comparing. Mechanical engineers, on average, tended to choose to work with fewer disciplines. It therefore became necessary to draw an additional sample of mechanical engineers. A delayed response from some mechanical engineers led to more invitations to participate. This also increased the number of mechanical engineers in the final sample. The same sampling procedures were followed for this supplemental sample selection. Table 10.2 summarizes the number of experts from different disciplines that reviewed each pair of exam outlines.

As a result of the oversampling of mechanical engineers, there were more expert pairs comparing mechanical engineering with all other disciplines than there were for other discipline pairs (11 to 15 paired comparisons with mechanical engineering vs. 6 to 9 between all others discipline pairs).

The participation rate was roughly comparable for all disciplines except electrical engineering. Between 56% and 81% of civil, mechanical and title act SMEs contacted participated compared with 40% of electrical engineers from both sources.[3] (Table 10.1)

Table 10.3 summarizes the mix of backgrounds of experts reviewing each of the discipline pairs. An effort was made to have half of the reviewers for a given discipline pair be licensed or recognized as an expert in one of the disciplines and half in the other. This occurred in 11 of 21 comparisons, counting 4/3 or 5/4 type splits as roughly half. Greater disparities in favor of the practice act disciplines occurred in ten of the comparisons -- six of them involving mechanical engineering -- while two favored title act disciplines (nuclear over civil and electrical).

Measurement of overlapping exam content. In order to understand how exam content overlap was calculated, it's helpful to take an example and work through each of the steps in the process. For reasons that will be discussed later in this section, the comparison between the industrial engineering exam and the computers depth module of the electrical and computer engineering exam is a particularly useful example. Table 10.4 shows the exam outline for industrial engineering. There are six major sections, each comprising between 12% and 25% of

[3] Electrical engineers were chosen from two source lists. The numbers responding from each list were combined into a single response rate of 40% (3 of 10 and 3 of 5 = 6 out of 15 or 40%).

the exam. Within each section more detailed topics are shown. Since subject matter experts were asked to compare outlines using the most detailed information available, the percent of the exam devoted to a section was distributed equally among these individual topics. For example, there are seven topics within the Facilities section, which comprises 25% of the exam, so each topic in this section is allocated $1/7^{th}$ of 25%, or 3.57%.

Table 10.4 also shows the percent of experts who identified overlapping topics on the two exam outlines. There were eight experts who compared these two outlines. None of the experts felt that the topics included in the Facilities section (1A-G) and the Production and Inventory Systems section (3A-G) of the industrial exam were covered anywhere in the computers depth module. Several topics (robotics, value engineering, human-machine interfacing, quality aspects of design, and productivity) were identified by just one expert (12.5%) as being covered on the computers depth module.

Not surprisingly, the only consensus regarding overlap concerns section 6 of the industrial exam outline – Management and Computer Information Systems. Seven of the experts (or 87.5%) said that computer systems analysis and design (6E on the industrial exam outline) was covered on the computers depth module. And six experts felt that specification of computer equipment and computer communication protocols (6F-G) from the industrial exam were covered on the computers depth module.

Multiplying the percent of the exam that each item contributes by the percent of experts who identified an equivalent item on the comparison exam produces a measure which reflects the relative importance of a topic on the outline, as well as the degree of agreement between the experts. This weighted percent overlap is shown in the last column of Table 10.4. A total of 6% of the content on the industrial exam is covered on the computers depth module.

Table 10.5 is based on the same expert review summarized in Table 10.4, but it reverses the direction of the overlap and shows the computations for measuring the percent of computers depth module content that is included on the industrial engineering exam. A much larger percent of the computers depth module content (28.86%) is covered on the industrial engineering exam.

Each pair of comparisons produces two different measures of overlap. Often the two measures are remarkably similar. This particular pair of comparisons was selected as an example because the difference between the two measures is so extreme. The measures describe a situation in which knowledge of management and computer information systems is a relatively minor part of the knowledge required by the industrial engineering exam. Since the computers module requires much more specialized knowledge of computers than the industrial exam, an engineer prepared only to pass the industrial exam would have difficulty passing the computers module. For industrial engineers, computers are a tool, not the focus of what they do. An engineer prepared to pass the computers module would appear to be well prepared to pass one section of the industrial exam, but would not necessarily have any knowledge of other more heavily emphasized areas required by the industrial exam.

Degree of Overlap between Disciplines

Overlap between practice act disciplines. Table 10.6 ranks the 148 discipline comparisons from the greatest amount of overlap to the least. Since there are two measures of overlap for each pair of comparisons, they are ordered according to the average amount of overlap. Most of the comparisons above the median (averaging 4.4% overlap) are practice/title act

comparisons (57/74 or 77%), while more of those below the median are practice/practice act comparisons (47/74 or 64%). In other words, there is more overlap between the title and practice disciplines than there is between the practice disciplines. In the lowest 20%, only 6 of 30 comparisons involve title and practice disciplines; 80% are combinations of practice act disciplines. Conversely, in the top 20%, only 3 of 30 comparisons involve two practice act disciplines; 90% are practice/title comparisons.

Twenty of the 30 comparisons with the least amount of overlap (1% or less) involve paired portions of the civil and electrical exams. Electrical and mechanical are also very dissimilar; 13 of 16 comparisons between the two are in the lower half of the ranking. On the other hand, there is much more overlap between civil and mechanical engineering; 14 of 24 comparisons between the two disciplines are in the upper half of the distribution. Overlap between these disciplines is greatest between the structural depth module and three mechanical exam modules (machine design, thermal & fluids systems, and breadth). The overlap between the structural and machine design modules is a balanced one: a fifth of each exam is found on the other one. In contrast, more content from the structural module appears on the mechanical breadth module than the reverse (17.6% vs. 11.1%). The same thing is true for overlap between the structural and the thermal & fluids systems modules. More content from the structural module appears on the thermal & fluids systems module (15.7%) and less material from thermal & fluids systems appears on the structural module (6.8%). It appears that the structural module is more specialized than the mechanical breadth and thermal & fluids systems modules. This suggests that someone with the knowledge required to pass the structural module would be better prepared for the mechanical breadth and thermal & fluids systems modules than the reverse.

There is also a significant amount of overlap between the civil and mechanical breadth modules (8.9% and 13.6%) and between the civil breadth and mechanical machine design modules (9.2% and 14.9%). The water resources and environmental modules both overlap with the mechanical breadth and thermal & fluids systems modules. The overlap between the water resources and mechanical breadth modules is 7.4% and 11.8%, for water resources and thermal & fluid systems it is 8.5% and 12.9%, for environmental and mechanical breadth it is 3.4% and 12.8%, and for environmental and thermal & fluids systems it is 4.1% and 14.3%. In each of these cases, a higher percentage of material on the mechanical exam appears on the civil exam than the reverse. (Table 10.7) It appears that in this instance, some of the mechanical modules are more specialized compared to the civil modules. This suggests that someone with the knowledge required to pass these mechanical modules would be better prepared for particular civil modules than the reverse.

The independence of exam content for two of the three pairs of practice act disciplines (between electrical and both civil and mechanical) strongly supports their separate disciplinary boundaries. But it also calls into question the one-directional allowable overlap of civil engineers into the other disciplines, particularly electrical engineering. Based on exam content, neither discipline should be engaged in the incidental practice of the other's responsibilities. There is a stronger case for bi-directional overlap between mechanical and civil engineering than there is for overlap in any direction between electrical and either civil or mechanical. (Table 10.6)

Overlap between practice and title act disciplines. The greatest amount of overlapping exam content between practice and title act disciplines occurs with modules on the mechanical (17 out of the top 30) and electrical (6 out of the top 30) exams. Overlaps involving mechanical exams are largely concentrated in the top 15. The title acts disciplines with the greatest amount

of overlap are chemical (6 out of 30), control systems (5), fire protection (5), industrial (4) nuclear (4), and manufacturing (3). Chemical and control systems are concentrated in the top 15, while fire protection is concentrated in the lower half of the top 30. The remaining 3 in the top 30 are pairings between civil and mechanical, two practice act disciplines. (Tables 10.6 and 10.7)

Looking at the top 30 comparisons with the greatest amount of average overlap, the chemical exam overlaps with four mechanical and two civil exams. The control systems exam overlaps with three mechanical and two electrical exams, while fire protection overlaps with three mechanical and two civil exams. The industrial exam overlaps more with the electrical (3) than mechanical modules (1), while nuclear does the reverse, overlapping more with mechanical (3) than electrical (1). All three of manufacturing's overlapped pairings are with mechanical exam modules. (Table 10.7)

Practice act discipline exam content makes up a higher percentage of the title act discipline exams in 8 of the top 30 comparisons, while title act content makes up a higher percentage of the practice act exams in 10 comparisons. In another nine, the amount of overlap is comparable (within 3% points) in both directions. The remaining three comparisons are between two practice act disciplines. In over half of the 30 comparisons, the proportion of overlapping content exceeds 20% for one or both exams. In the four pairings of chemical and mechanical in the top 30, the overlap is between 28% and 40%, with two equally balanced and the others weighted toward chemical. The extent of overlapping exam content between these two disciplines argues against the current licensing system that permits one directional overlap by mechanical engineers into chemical engineering, prohibiting the reverse. In the cases of unbalanced overlap, the content from the chemical exam makes up a higher proportion of the mechanical exam than the reverse -- suggesting that the chemical engineering exam requires more specialized knowledge than the mechanical modules. (Table 10.6)

Percentage of title acts' exam content covered on practice acts' exams. From the perspective of the title acts, most of the overlap with practice act discipline exams is on the mechanical breath and depth modules. Roughly a third of the chemical exam is covered on the mechanical breadth and depth modules, especially the HVAC & refrigeration and thermal & fluids systems modules. A slightly smaller percentage (20.9%) of the chemical exam content is found in the civil environmental depth module. Almost a fifth of the control systems, fire protection and manufacturing exams are covered on the mechanical breadth module (19%, 17.5% and 16.7% respectively) and the thermal & fluids systems module (16.9%, 17.0% and 14.7% respectively). Fire protection has a similar degree of overlap with the civil breadth module (16.4%). In addition, a fourth of the control systems and fire protection exam content is covered by the HVAC & refrigeration module and a third of the manufacturing exam content is found on the machine design module. (Table 10.8)

Percentage of practice acts' exam content covered on title acts' exams. From the perspective of civil engineering, most of the overlap with other discipline exams is in the environmental, structural and water resources depth modules. A fourth of the environmental module is found on the chemical exam and 15% is covered on the industrial exam. The water resources module also overlaps with the chemical exam (15.24%). Finally, material making up 16% to 21% of the structural module is found on the mechanical breadth module and two of mechanical depth modules (machine design and thermal & fluids systems). (Table 10.9)

From the perspective of electrical engineering, most of the overlap with other discipline exams is in control systems, industrial and nuclear. Between 17% and 29% of the electrical breadth,

computers and power modules are found on the industrial exam (17%, 29% and 22% respectively). Roughly a fifth of the computers and electronics modules are found on the control systems exam (24% and 22% respectively). A similar percentage of the electronics module is found on the nuclear exam (22%). (Table 10.10)

From the perspective of mechanical engineering, most of the overlap in exam content is with the title act disciplines, especially chemical. Roughly a third of the content on the mechanical breadth, HVAC & refrigeration and thermal & fluids systems modules are found on the chemical exam. A similar proportion of the machine design module is found on the manufacturing exam, along with 16% of the mechanical breadth module. Approximately a fifth of the mechanical breadth, HVAC & refrigeration and thermal & fluids systems modules are found on the control systems exams. A similar proportion of the thermal & fluids systems module is found on the nuclear exam. Finally, roughly 15% of the machine design and thermal & fluids systems modules are found on the industrial exam and a similar percentage of the mechanical breadth module on the nuclear exam. The one noticeable overlap with a practice act discipline occurs with the civil structural depth module -- 22% of the machine design module appears on the structural module. (Table 10.11)

Overlap reflected in dual licenses. Areas of significant overlap described above are also reflected in discipline combinations found among those with dual licenses. The two title act disciplines with the highest percentages of dual licenses were not included in the exam outline comparisons because of either limited numbers of licensees (agricultural engineering with 20% holding a civil license and 4% a mechanical license) or the absence of an NCEES exam (traffic engineering with 36% holding a civil license). Discipline combinations with the greatest amount of overlap in exam content that also had significant numbers of dual licenses include: nuclear (15% had a mechanical license), control systems (7% had an electrical license and 5%, a mechanical license), fire protection (7% had a mechanical license and 4% a civil license), metallurgical (4% had a mechanical license), industrial (3% had a mechanical license) and chemical (3% had a mechanical license).

Consistent with the lack of overlap in exam content and the one-directional overlap permitted by the regulatory structure, less than 1% of civil engineers had dual licenses involving the other practice act disciplines and less than 1% of electrical engineers had a civil license as well. Between 1 and 2% of mechanical engineers had licenses in civil and electrical.

The order in which dual licenses were obtained is also of interest. Of those with dual licenses, a slight majority of the practice act engineers obtained their civil license first (55% and 54% for electrical and mechanical engineers). For the title act disciplines with meaningful numbers of cases, most of those with dual licenses obtained the civil first, ranging from 69% for agricultural engineers to 97% for fire protection. Control systems engineers with electrical and mechanical licenses also obtained the practice license first; 75% obtained the electrical and 53% the mechanical before obtaining the control systems license. The same was true for fire protection and nuclear engineers with mechanical licenses; 77% and 57% respectively obtained the practice license first. Only chemical engineers obtained the mechanical license second (84%). (Table 10.13)

Nature of Overlapping Content

Where significant overlap in exam content exists, it is of interest to consider more specifically what these exams have in common. Up to this point, this chapter has focused on the relative amount of overlap between pairs of exams. But now that the analysis is shifting to the more

detailed location of this overlap, the most useful measure is the percent of experts who identified overlap between two particular exam areas.

ISR chose to explore in more depth those pairings where the proportion of overlapping content exceeded 15% on at least one of the paired exams. This decision rule led, coincidentally, to a more detailed comparison of overlapping content for 30 pairings of exam modules. The discipline pairings are described in Table 10.14. While most of the pairings in the top 30 -- ranked in terms of the average amount of overlap on the two paired exam modules -- are included in this part of the analysis, some fell out because they didn't meet the 15% threshold on at least one exam and others not in the top 30 were included because they did. There are two more pairings of industrial with practice act disciplines and two fewer pairings involving fire protection. One of the nuclear pairings fell out, while an additional pair of civil and mechanical made the cut.

Chemical engineering and practice act exam modules. The subject matter experts identified similarities between the Fluids and Heat Transfer sections of the chemical exam and several sections of the thermal & fluids systems module. Half or more of the 11 experts found overlap between these two sections of the chemical exam and the Engineering Principles, Hydraulic System Components, Power Plant Components and Systems Applications sections of the thermal & fluids systems module. The Engineering Principles section of the thermal & fluids systems module also overlapped with chemical exam sections on Mass and Energy Balances, Thermodynamics and Plant Design. The System Applications section of the thermal & fluids systems module overlaps with the chemical exam section on Thermodynamics. (Table 10.15)

Some of the same areas on the chemical exam (HeatTransfer, Fluids, Thermodynamics and to a lesser extent Mass and Energy Balances, Mass Transfer and Plant Design) overlapped with the HVAC & refrigeration module. This was particularly true of the Principles, Equipment and Materials and Systems Applications sections. These sections make up most of the HVAC & refrigeration module and the corresponding areas, most of the chemical engineering exam.

Most of the experts saw significant overlap between five of the seven areas on the chemical exam and the Supportive Knowledges and System Applications sections of the machine design module. However, these sections make up only 21% of this module. Slightly less than half of the experts saw similarities in the chemical exam section on Plant Design and the more important Engineering Principles portion of the machine design module.

A majority of experts saw overlap between the Heat Transfer, Fluids and Plant Design sections of the chemical exam and the General Knowledge, Codes and Standards topic area, specifically the Engineering Principles or Fundamentals of Engineering Practice portions, of the mechanical breadth module. The other part of this module with significant overlap was in the Energy Conversion/Power Systems Knowledge area, which overlapped with Mass and Energy Balances, Fluids and Thermodynamics on the chemical exam. (Table 10.15)

Finally, portions of the chemical exam outline overlapped with sections of the water resources and environmental topics on the environmental and water resources modules of the civil engineering exam. All experts agreed that the Fluids section of the chemical exam overlapped with Hydraulics on the Water Resources sections of the two civil depth modules. Others, ranging from 43% to 71%, saw comparability between the Plant Design section of the chemical exam and the water and wastewater treatment, biology and solid/hazardous waste sections of the two civil engineering depth modules. A similar proportion (43%) saw similarities between the

chemical exam section on Thermodynamics and the environmental module section on Wastewater Treatment. (Table 10.15)

Control systems engineering and practice act exam modules. Different parts of the control systems exam overlap with various sections of the mechanical and electrical modules. Between 93% and 100% of 14 experts agreed that overlap occurs between the control systems exam sections on Valves & Final Elements and Process Dynamics and the HVAC & refrigeration and thermal &fluids systems module sections on Engineering Principles. There is also significant agreement that the same sections of the control systems exam overlap the Engineering Principles (79% and 86%) and Analysis of Systems & Components (57%) portions of the mechanical breadth module. Together, the two control systems sections make up 20% of that exam; the identified sections on the mechanical depth modules make up similar proportions of those exams (19% and 22%) while the Engineering Principles section on the breadth module is 15%. In short, there is widespread agreement among 14 experts concerning overlapping content on substantial sections of the control systems and mechanical engineering exams. (Table 10.16)

A secondary area of overlap involves the control systems exam sections on Documentation and the Economics of Control. Most experts (79%) perceived similarities between Economics of Control and the Supportive Knowledges section of the HVAC & refrigeration module, the Engineering Principles section of the thermal & fluids systems module, and the Fundamental Engineering Practice section of the mechanical breadth module. However, Economics of Control makes up only 2% of the control systems exam. Documentation, making up 8% of that exam, also overlaps with the Fundamental Engineering Practice section of the mechanical breadth module and with the Development and Applications section of the electrical engineering computers depth module, which makes up almost a fourth of that exam. The control systems exam section on Codes and Standards (10% of that exam) is seen as similar to parallel sections on the electronics module and mechanical breadth module -- sections that are less important on those exams (4%) -- and to the Application Supportive Knowledge section of the thermal & fluids systems module, where the topic is given more importance (8%). (Table 10.16)

Almost half of the experts believed that the most important section of the control systems exam, Discrete Logic, Interlocks, Alarms and Sequencing (18%) overlapped with the similarly weighted (16%) computers module section on Digital Electronics. The same proportion of experts saw a connection between the control systems exam section on Digital Control Systems (8% of the exam) and the computers module section on System Software (12% of the exam). (Table 10.16)

Roughly half also saw similarities between the control systems exam sections on Analog & Digital Data Transmission and the electronics depth module sections on Communication & Signal Processing and Telecommunications, as well as the computers depth module section on Networks. Over half also perceived that Sensors, an important area on control systems' exam (16%), overlapped with Measurement and Instrumentation on the electronics depth module (4%) and Equipment and Materials on the HVAC & refrigeration module (37%). (Table 10.16)

Thus, the more significant overlaps involving control systems occurred: 1) between the control systems exam section on Valves & Final Elements and the mechanical exam sections on Engineering Principles and Fundamentals; 2) between the control systems section on Sensors and the HVAC & refrigeration module section on Equipment and Materials, and; 3) between the control systems section on Discrete Logic, etc. and the computer depth module section on Digital Electronics. (Table 10.16)

Fire protection engineering and practice act exam modules. Although a few experts saw overlap in many sections of these pairings, the only areas with significant agreement (43% or more) involved the Building systems section of the fire protection exam and portions of the structural depth module (Materials and Design Criteria), the mechanical breadth module (Applications of Machine Design and Materials Knowledge) and the thermal & fluids systems module (Engineering Principles). (Table 10.17)

Industrial engineering and practice act exam modules. The two most significant sections of the industrial exam, Facilities and Manufacturing, each make up 25% of the exam content. Overlap for the industrial exam section on Manufacturing is concentrated in mechanical engineering – both in the machine design module section on Systems Applications and Supportive Knowledges, and in the thermal & fluids systems module section on Engineering Principles. Overlap for the industrial exam section on Facilities is more dispersed -- in the environmental module section on Solid/Hazardous Waste, in the electrical breadth module section on Transmission and Distribution, and in the power depth module sections on Measurement, Instrumentation and Statistics, System Analysis and Power System Performance. (Table 10.18)

Material on the industrial exam section on Management (13% of the exam) overlaps with topics of moderate importance on the computers depth module -- Systems, System Software, and Networks. Quality Assurance, an area of comparable strength on the industrial exam (12%), overlaps with an area of moderate importance on the machine design module (Supportive Knowledges), and an area of less importance on the electrical breadth module (Safety and Reliability). (Table 10.18)

Manufacturing engineering and practice act exam modules. The only practice act discipline exam that overlaps with the manufacturing exam is mechanical engineering. In terms of weights on the respective exams, the most important areas of overlap involve manufacturing exam sections on Product/Process Design and Production, Systems and Control sections (21% and 17% respectively). These sections overlap with the thermal & fluids systems module section on Engineering Principles, the machine design module section on Systems Applications, and the mechanical breadth module section on Fundamental Engineering Practice. Between 64% and 79% of 14 experts agree on these areas of overlap. (Table 10.19)

Similar levels of agreement occurred in other less important areas. The manufacturing exam section on Management overlaps with the mechanical breadth exam section on Fundamental Engineering Practice, as well as the machine design module section on Supportive Knowledges and the thermal & fluids systems module section on Engineering Principles.

Manufacturing exam sections on Quality and Fabrication, Joining & Assembly also overlap with machine design module sections on Supportive Knowledges. Materials Engineering and Applications, an area of limited importance (6%) on the manufacturing exam, overlaps with the Engineering Principles section of three of the mechanical exam modules. The Engineering Principles section is 43% of the machine design module, 22% of the thermal & fluids systems module, and 15% of the mechanical breadth module. Finally, areas of limited importance on both exams – the manufacturing exam section on Materials Engineering & Applications (6%) and the machine design module section on Applications (6%) -- overlap. (Table 10.19)

Nuclear engineering and practice act exam modules. Two important parts of the nuclear exam (Power Systems and Fuel & Waste Management-- 25% and 20% respectively) overlap

with important sections of the thermal & fluids systems module (Engineering Principles, Systems Applications and Power Plant Components). These same sections of the nuclear exam overlap with parallel, but less heavily weighted, parts of the mechanical breadth exam (Engineering Principles, Fundamental Engineering Practice and Analysis of Systems and Components). (Table 10.20)

A less heavily weighted section of the nuclear exam, Measurements and Instruments (15%), overlaps with less important sections of the electronics module -- Measurement and Instrumentation (4%), Control System Fundamentals (10%) and Control System Design/Implementation (6%). (Table 10.20)

Mechanical and civil modules. Engineering Principles is major section of the machine design module, with 43% of the exam content. This section overlaps with the Structural section of the civil breadth module (20% of that exam) and with the structural depth module section on Materials and Failure Analysis. Areas of less importance on the machine design module -- System Applications (13%) and Supportive Knowledges (18%) – overlap, respectively, with the Structural and Water Resources sections of the civil breadth exam. (Table 10.21). In addition to the important overlap between the Mechanics of Materials and Failure Analysis on the structural module and the machine design module just described, the same areas overlap with the less important Supportive Knowledges section of the thermal & fluids systems module. (Table 10.22)

Table 10.1 Contact and Participation Rates for Subject Matter Experts Reviewing NCEES Exam Outlines

			Enforcement Technical Experts[c]			Electrical Engineering TAC	Title Act Subject Matter Experts[d]	All
			Civil	Mechanical	Electrical			
Percent	Ability to contact	Unable to contact[a]	40%	35%	33%	0%	26%	31%
		Contacted	60%	65%	67%	100%	74%	69%
		Total	100%	100%	100%	100%	100%	100%
	Outcome for those contacted	Contacted but unable to participate[b]	11%	5%	20%	0%	8%	9%
		Left messages, but calls not returned	0%	5%	40%	0%	0%	7%
		Invitation to participate sent	33%	20%	10%	20%	8%	16%
		Comparison documents sent	0%	5%	0%	20%	4%	4%
		Participated	56%	65%	30%	60%	81%	64%
		Total	100%	100%	100%	100%	100%	100%
Number	Ability to contact	Unable to contact[a]	6	11	5	0	9	31
		Contacted	9	20	10	5	26	70
		Total	15	31	15	5	35	101
	Outcome for those contacted	Contacted but unable to participate[b]	1	1	2		2	6
		Left messages, but calls not returned		1	4			5
		Invitation to participate sent	3	4	1	1	2	11
		Comparison documents sent	0	1	0	1	1	3
		Participated	5	13	3	3	21	45
		Total	9	20	10	5	26	70

[a] Non-working phone number, ill or deceased.

[b] Some experts felt they were not qualified to participate because they were retired, while other were not able to take on the additional work.

[c] For the purpose of this study, the Board made available their database of Enforcement Technical Experts, which consisted of 98 Civil Engineers, 40 Mechanical Engineers, and 32 Electrical Engineers. A random sample of 15 experts was drawn from each discipline. The list of experts within each discipline was ordered by license number, which provides a rough measure of years of experience as a licensed engineer, and divided into three equal strata. A systematic sample of five experts was selected from each stratum, producing an initial sample of 15 experts from each discipline. For reasons described in the following paragraph, it became necessary to draw an additional sample of Mechanical Engineers. The same sampling procedures were followed for this supplemental sample selection.

The objective was to have roughly equal numbers of experts from each pair of disciplines review the exam outlines. For example, for the comparison between Civil and Mechanical Engineering exam outlines, ideally half the reviewers should be licensed Civil Engineers and half should be licensed Mechanical Engineers. All experts were asked to indicate which disciplines they felt comfortable working with. Mechanical engineers, on average, tended to choose to work with fewer disciplines, thus the need to select more of them.

[d] The Board provided a list of 38 Title Act Subject Matter Experts. Three of these experts were not contacted because their areas of knowledge were not currently being examined. Table 10.3 shows the licensing and expertise for all of the experts.

Table 10.2 Number of Experts who Reviewed Each Pair of Exam Outlines

	Civil	Electrical & Computer	Mechanical
Electrical & Computer	9		
Mechanical	14	13	
Chemical	7	7	11
Control Systems	6	7	14
Fire Protection	7	7	13
Industrial	9	8	13
Manufacturing	8	6	14
Nuclear	6	6	15

Table 10.3. Selection Criteria for Experts Comparing Pairs of NCEES Exam Outlines

		Civil				Electrical & Computer				Mechanical			
		No special knowledge	Current license in discipline	Board designated expert	Total	No special knowledge	Current license in discipline	Board designated expert	Total	No special knowledge	Current license in discipline	Board designated expert	Total
Electrical & Computer	No special knowledge		5		5								
	Current license in discipline	3			3								
	Board-designated expert			1	1								
	Total	3	5	1	9								
Mechanical	No special knowledge		5		5		6		6				
	Current license in discipline	5	2	1	8	5			5				
	Expired license in discipline			1	1			1	1				
	Board-designated expert							1	1				
	Total	5	7	2	14	5	6	2	13				
Chemical	No special knowledge		3		3		3		3		7		7
	Current license in discipline	4			4	4			4		2	2	4
	Total	4	3		7	4	3		7		9	2	11
Control	No special knowledge		4		4		4		4	1	11		12
	Current license in discipline	2			2	2			2	2			2
	Board-designated expert							1	1				
	Total	2	4		6	2	4	1	7	3	11		14
Fire	No special knowledge		4		4		4		4		10		10
	Current license in discipline	1			1			1	1			1	1
	Expired license in discipline	1			1	1			1	1			1
	Board-designated expert	1			1	1			1			1	1
	Total	3	4		7	2	4	1	7	1	10	2	13
Industrial	No special knowledge		5		5		4		4		9		9
	Current license in discipline	1			1	1			1	1			1
	Board-designated expert	3			3	2		1	3	2		1	3
	Total	4	5		9	3	4	1	8	3	9	1	13
Manufacturing	No special knowledge		5		5		3		3		11		11
	Board-designated expert	3			3	2		1	3	3			3
	Total	3	5		8	2	3	1	6	3	11		14
Nuclear	No special knowledge		2		2		1		1		9		9
	Current license in discipline	3			3	3			3	3			3
	Expired license in discipline	1			1	1			1	1			1
	Board-designated expert							1	1	1	1		2
	Total	4	2		6	4	1	1	6	5	10		15

Table 10.4. Computation of Percent of Industrial Engineering Exam Content
Covered on the Computers Depth Module of the Electrical and Computer Engineering Exam

			Approximate Percentage of Examination	Percent of Experts Identifying Overlap	Weighted Percent Overlap
1. Facilities (25%)	A.	Site selection	3.57%		
	B.	Plant layout	3.57%		
	C.	Equipment	3.57%		
	D.	Material handling and waste management systems	3.57%		
	E.	Packaging equipment	3.57%		
	F.	Capacity analysis	3.57%		
	G.	Power service and other utility requirements	3.57%		
2. Manufacturing (25%)	A.	Products	3.13%		
	B.	Manufacturing processes	3.13%		
	C.	Maintenance procedures	3.13%		
	D.	Operations sequencing	3.13%		
	E.	Machine grouping	3.13%		
	F.	Robotics	3.13%	12.5%	.39%
	G.	Automation	3.13%		
	H.	Value engineering	3.13%	12.5%	.39%
3. Production and Inventory Systems (12%)	A.	Forecasting	1.71%		
	B.	Production scheduling	1.71%		
	C.	Project scheduling	1.71%		
	D.	Production control	1.71%		
	E.	Resource planning	1.71%		
	F.	Logistics	1.71%		
	G.	Distribution	1.71%		
4. Work Systems and Ergonomics (13%)	A.	Measuring work	2.17%		
	B.	Methods analysis	2.17%		
	C.	Incentive and other payment plans	2.17%		
	D.	Workplace design	2.17%		
	E.	Human-machine interfacing	2.17%	12.5%	.27%
	F.	Industrial hygiene and safety	2.17%		
5. Quality Assurance (12%)	A.	Quality assurance plans	2.40%		
	B.	Reliability analysis	2.40%		
	C.	Control procedures	2.40%		
	D.	Capability analysis	2.40%		
	E.	Quality aspects of design	2.40%	12.5%	.30%
6. Management and Computer/ Information Systems (13%)	A.	Organization design	1.86%		
	B.	Staffing plans	1.86%		
	C.	Productivity	1.86%	12.5%	.23%
	D.	Human resources	1.86%		
	E.	Computer systems analysis and design	1.86%	87.5%	1.63%
	F.	Specification of computer equipment	1.86%	75.0%	1.39%
	G.	Computer communication protocols	1.86%	75.0%	1.39%
Total			100.00%	N=8	5.99%

Percentages shown in parentheses in the first column are the approximate percentage of the examination provided by NCEES in the exam outline.

Table 10.5. Computation of Percent of the Computers Depth Module of the Electrical and Computer Engineering Exam Content Covered on the Industrial Engineering Exam

				Approximate Percentage of Examination	Percent of Experts Identifying Overlap	Weighted Percent Overlap
1. General Computer Systems (10%)	A. Interpretation of Codes and Standards (4%)	1) IEEE Standards		2.00%	37.5%	.75%
		2) ISO Standards		2.00%	37.5%	.75%
	B. Micro-processor Systems (6%)	1) Number Systems and Codes		1.00%	25.0%	.25%
		2) Microprocessor Systems	a) Components	1.00%	25.0%	.25%
			b) Control Applications	1.00%	37.5%	.38%
			c) Math Applications	1.00%	25.0%	.25%
			d) Programmable Logic Controllers	1.00%	25.0%	.25%
			e) Real-time Operations	1.00%	37.5%	.38%
2. Hardware (45%)	A. Digital Electronics (16%)	1) Memory Devices		1.60%	12.5%	.20%
		2) Medium Scale Integration Devices		1.60%	12.5%	.20%
		3) Programmable Logic Devices and Gate Arrays		1.60%	12.5%	.20%
		4) Tristate Logic		1.60%	12.5%	.20%
		5) Digital Electronic Devices		1.60%	12.5%	.20%
		6) Logic Components	a) Properties	1.60%	12.5%	.20%
			b) Fan-In, Fan-Out	1.60%	12.5%	.20%
			c) Propagation Delay	1.60%	12.5%	.20%
		7) Large Scale Integration		1.60%	12.5%	.20%
		8) Analog to Digital and Digital to Analog Conversion		1.60%	12.5%	.20%
	B. Design and Analysis (19%)	1) Clock Generation/Distribution		1.27%	12.5%	.16%
		2) Memory Interface		1.27%	12.5%	.16%
		3) Processor Interfacing		1.27%	12.5%	.16%
		4) Asynchronous Communication		1.27%	12.5%	.16%
		5) Metastability		1.27%	12.5%	.16%
		6) Races and Hazards		1.27%	12.5%	.16%
		7) State Transition Tables		1.27%	12.5%	.16%
		8) State Transition Diagrams		1.27%	12.5%	.16%
		9) Algorithmic State Machine Charts		1.27%	12.5%	.16%
		10) Timing Diagrams		1.27%	12.5%	.16%
		11) Synchronous State Machines		1.27%	12.5%	.16%
		12) Asynchronous State Machines		1.27%	12.5%	.16%
		13) Pipelining and Parallel Processing		1.27%	12.5%	.16%
		14) Fault Tolerance		1.27%	12.5%	.16%
		15) Sampling Theory		1.27%	12.5%	.16%
	C. Systems (10%)	1) Digital Signal Processor Architecture		1.67%	62.5%	1.04%
		2) Design for Testability		1.67%	87.5%	1.46%
		3) Computer Architecture		1.67%	62.5%	1.04%
		4) Mass Storage Devices		1.67%	62.5%	1.04%
		5) Input/Output Devices		1.67%	75.0%	1.25%
		6) Central Processing Unit Architecture		1.67%	75.0%	1.25%

Percentages shown in parentheses in the first and second columns are the approximate percentage of the examination provided by NCEES in the exam outline.

Table 10.5. (continued) Computation of Percent of the Computers Depth Module of the Electrical and Computer Engineering Exam Content Covered on the Industrial Engineering Exam

				Approximate Percentage of Examination	Percent of Experts Identifying Overlap	Weighted Percent Overlap
3. Software (35%)	A. System Software (12%)	1) Computer Security		2.40%	37.5%	.90%
		2) Real-Time Operating Systems		2.40%	50.0%	1.20%
		3) Error Detection and Control		2.40%	37.5%	.90%
		4) Drivers		2.40%	37.5%	.90%
		5) Time Critical Scheduling		2.40%	25.0%	.60%
	B. Development/ Applications (23%)	1) Computer Control and Monitoring		1.10%	25.0%	.27%
		2) Software Lifecycle	a) Requirements Definition	1.10%	25.0%	.27%
			b) Specification	1.10%	25.0%	.27%
			c) Design	1.10%	25.0%	.27%
			d) Implementation and Debugging	1.10%	25.0%	.27%
			e) Testing	1.10%	37.5%	.41%
			f) Maintenance and Upgrade	1.10%	12.5%	.14%
		3) Fault Tolerance		1.10%	25.0%	.27%
		4) Modeling and Simulation		1.10%	50.0%	.55%
		5) Software Pipelining		1.10%	12.5%	.14%
		6) Human Interface Requirements		1.10%	25.0%	.27%
		7) Software Design Methods and Documentation	a) Structured Programming	1.10%	12.5%	.14%
			b) Top Down or Bottom Up Programming	1.10%	12.5%	.14%
			c) Successive Refinement	1.10%	12.5%	.14%
			d) Programming Specifications	1.10%	12.5%	.14%
			e) Program Testing	1.10%	25.0%	.27%
			f) Structure Diagrams	1.10%	12.5%	.14%
			g) Recursion	1.10%	12.5%	.14%
		8) Object Oriented Design		1.10%	12.5%	.14%
		9) Data Structures	a) Internal	1.10%	12.5%	.14%
			b) External	1.10%	12.5%	.14%
4. Networks (10%)	A. Networks	1) Protocols	a) TCP/IP	1.67%	75.0%	1.25%
			b) Ethernet	1.67%	75.0%	1.25%
		2) Computer Networks	a) OSI Model	1.67%	37.5%	.63%
			b) Network Topology	1.67%	37.5%	.63%
			c) Network Technology	1.67%	37.5%	.63%
			d) Network Security	1.67%	37.5%	.63%
Total				100.00%	N=8	28.86%

Percentages shown in parentheses in the first and second columns are the approximate percentage of the examination provided by NCEES in the exam outline.

Table 10.6. Percent of Overlapping Content Among Practice and Title Discipline Exam Outlines (in Average Rank Order)

* Comparison Between Practice Act Disciplines	1st Discipline	2nd Discipline	Percent of 2nd Discipline's Exam Content Found on the 1st	Percent of 1st Discipline's Exam Content Found on the 2nd	Rank on 1st%	Rank on 2nd%	Average Rank Order
	Mechanical HVAC Module	Chemical	39.7%	39.9%	1	1	1
	Mechanical Breadth Module	Chemical	33.7%	34.0%	3	2	2.5
	Mechanical Thermal and Fluids Systems Module	Chemical	38.1%	31.1%	2	3	2.5
	Mechanical Machine Design Module	Manufacturing	32.3%	30.5%	4	4	4
	Electrical Electronics Module	Control Systems	30.7%	21.7%	5	10	7.5
	Civil Environmental Depth Module	Chemical	20.9%	24.1%	10	6	8
*	Civil Structural Depth Module	Mechanical Machine Design Module	21.7%	20.5%	9	13	11
	Mechanical HVAC Module	Control Systems	24.3%	19.0%	8	15	11.5
	Mechanical Breadth Module	Control Systems	19.0%	19.3%	11	14	12.5
	Mechanical Thermal and Fluids Systems Module	Control Systems	16.9%	20.6%	14	12	13
	Mechanical Breadth Module	Manufacturing	16.7%	16.0%	15	19	17
	Mechanical Thermal and Fluids Systems Module	Nuclear	13.9%	21.4%	26	11	18.5
	Mechanical Machine Design Module	Chemical	27.5%	10.8%	6	33	19.5
	Electrical Computers Depth Module	Control Systems	12.3%	23.5%	33	7	20
	Mechanical Breadth Module	Nuclear	15.6%	15.1%	18	24	21
	Mechanical Machine Design Module	Industrial	14.0%	16.4%	25	18	21.5
	Mechanical Thermal and Fluids Systems Module	Manufacturing	14.7%	13.1%	21	27	24
	Mechanical Breadth Module	Fire Protection	17.5%	10.1%	12	38	25
*	Civil Structural Depth Module	Mechanical Breadth Module	11.1%	17.6%	36	16	26
	Civil Water Resources Depth Module	Chemical	13.1%	15.2%	29	23	26
	Civil Structural Depth Module	Fire Protection	15.3%	10.7%	19	34	26.5
	Mechanical Thermal and Fluids Systems Module	Fire Protection	17.0%	9.3%	13	41	27
	Electrical Electronics Module	Nuclear	7.5%	22.0%	48	8	28
	Electrical Computers Depth Module	Industrial	6.0%	28.9%	53	5	29
	Electrical Breadth Module	Industrial	9.6%	17.3%	42	17	29.5
	Civil Water Resources Depth Module	Fire Protection	14.3%	10.2%	23	37	30
	Mechanical HVAC Module	Nuclear	14.4%	10.1%	22	39	30.5
	Mechanical HVAC Module	Fire Protection	26.9%	6.6%	7	54	30.5
*	Civil Breadth Module	Mechanical Machine Design Module	14.9%	9.2%	20	42	31
	Electrical Power Module	Industrial	5.9%	21.9%	54	9	31.5
	Electrical Breadth Module	Manufacturing	12.6%	11.0%	32	32	32
	Mechanical Thermal and Fluids Systems Module	Industrial	8.7%	15.3%	44	22	33
*	Civil Structural Depth Module	Mechanical Thermal and Fluids Systems Module	6.8%	15.7%	49	20	34.5
	Civil Breadth Module	Chemical	11.4%	10.6%	35	35	35
*	Civil Breadth Module	Mechanical Breadth Module	13.6%	8.9%	27	43	35
	Mechanical Breadth Module	Industrial	9.3%	12.0%	43	28	35.5

Table 10.6. (continued) Percent of Overlapping Content Among Practice and Title Discipline Exam Outlines (in Average Rank Order)

* Comparison Between Practice Act Disciplines	1st Discipline	2nd Discipline	Percent of 2nd Discipline's Exam Content Found on the 1st	Percent of 1st Discipline's Exam Content Found on the 2nd	Rank on 1st%	Rank on 2nd%	Average Rank Order
	Civil Breadth Module	Fire Protection	16.4%	6.6%	16	55	35.5
	Electrical Breadth Module	Control Systems	9.8%	11.5%	41	31	36
*	Civil Water Resources Depth Module	Mechanical Thermal and Fluids Systems Module	12.9%	8.5%	30	46	38
	Civil Environmental Depth Module	Industrial	5.5%	15.4%	60	21	40.5
	Electrical Breadth Module	Nuclear	6.2%	11.5%	51	30	40.5
	Civil Environmental Depth Module	Fire Protection	16.1%	5.5%	17	66	41.5
	Civil Water Resources Depth Module	Control Systems	5.6%	13.1%	58	26	42
	Electrical Breadth Module	Fire Protection	10.1%	8.6%	40	45	42.5
*	Civil Water Resources Depth Module	Mechanical Breadth Module	11.8%	7.4%	34	51	42.5
	Mechanical HVAC Module	Industrial	4.9%	13.5%	64	25	44.5
*	Civil Breadth Module	Mechanical Thermal and Fluids Systems Module	8.6%	8.4%	45	47	46
	Mechanical Machine Design Module	Nuclear	11.0%	6.6%	37	56	46.5
*	Electrical Breadth Module	Mechanical Breadth Module	5.4%	10.5%	61	36	48.5
	Electrical Breadth Module	Chemical	4.6%	11.9%	70	29	49.5
	Mechanical Machine Design Module	Fire Protection	10.2%	5.7%	39	62	50.5
	Electrical Power Module	Fire Protection	8.1%	6.3%	47	57	52
*	Civil Environmental Depth Module	Mechanical Thermal and Fluids Systems Module	14.3%	4.1%	24	81	52.5
	Civil Transportation Depth Module	Fire Protection	13.4%	4.6%	28	78	53
	Mechanical Machine Design Module	Control Systems	10.4%	5.0%	38	71	54.5
	Civil Breadth Module	Industrial	4.9%	8.4%	64	47	55.5
	Civil Environmental Depth Module	Control Systems	6.5%	5.5%	50	64	57
	Civil Transportation Depth Module	Industrial	4.8%	7.4%	66	50	58
*	Civil Environmental Depth Module	Mechanical Breadth Module	12.8%	3.4%	31	86	58.5
	Civil Environmental Depth Module	Manufacturing	3.8%	9.9%	78	40	59
	Civil Environmental Depth Module	Nuclear	8.5%	4.9%	46	72	59
	Electrical Computers Depth Module	Manufacturing	4.8%	6.7%	66	53	59.5
	Mechanical HVAC Module	Manufacturing	5.9%	5.5%	54	65	59.5
	Civil Breadth Module	Control Systems	6.1%	5.4%	52	67	59.5
	Electrical Power Module	Manufacturing	3.5%	8.9%	82	44	63
*	Civil Water Resources Depth Module	Mechanical HVAC Module	4.8%	6.2%	68	58	63
*	Electrical Breadth Module	Mechanical Thermal and Fluids Systems Module	3.7%	7.5%	80	49	64.5
*	Civil Transportation Depth Module	Mechanical Breadth Module	5.7%	4.9%	57	73	65
*	Electrical Power Module	Mechanical Thermal and Fluids Systems Module	4.6%	5.7%	71	60	65.5
	Civil Water Resources Depth Module	Industrial	4.1%	5.6%	75	63	69
*	Civil Transportation Depth Module	Mechanical Thermal and Fluids Systems Module	4.7%	4.8%	69	74	71.5
*	Civil Environmental Depth Module	Mechanical HVAC Module	5.8%	3.0%	56	88	72

Table 10.6. (continued) Percent of Overlapping Content Among Practice and Title Discipline Exam Outlines (in Average Rank Order)

* Comparison Between Practice Act Disciplines	1st Discipline	2nd Discipline	Percent of 2nd Discipline's Exam Content Found on the 1st	Percent of 1st Discipline's Exam Content Found on the 2nd	Rank on 1st%	Rank on 2nd%	Average Rank Order
	Civil Breadth Module	Manufacturing	4.4%	4.8%	73	74	73.5
	Electrical Power Module	Control Systems	5.0%	4.0%	63	84	73.5
	Civil Breadth Module	Nuclear	5.6%	2.8%	58	90	74
*	Civil Water Resources Depth Module	Mechanical Machine Design Module	2.8%	5.8%	90	59	74.5
	Civil Structural Depth Module	Industrial	3.6%	5.1%	81	70	75.5
*	Civil Geotechnical Depth Module	Mechanical Machine Design Module	4.6%	4.2%	71	80	75.5
	Civil Structural Depth Module	Manufacturing	3.4%	5.2%	83	69	76
	Electrical Electronics Module	Chemical	1.3%	7.2%	104	52	78
	Electrical Electronics Module	Fire Protection	5.3%	1.3%	62	101	81.5
	Civil Transportation Depth Module	Control Systems	2.0%	5.2%	96	68	82
	Civil Transportation Depth Module	Chemical	2.8%	4.3%	88	79	83.5
*	Civil Geotechnical Depth Module	Mechanical Breadth Module	2.5%	4.7%	92	76	84
	Electrical Computers Depth Module	Fire Protection	4.0%	2.5%	76	92	84
	Electrical Computers Depth Module	Chemical	1.1%	5.7%	109	61	85
	Electrical Power Module	Nuclear	2.2%	4.6%	94	77	85.5
	Civil Geotechnical Depth Module	Fire Protection	4.0%	1.8%	76	96	86
*	Civil Transportation Depth Module	Mechanical HVAC Module	2.8%	3.3%	88	87	87.5
*	Civil Breadth Module	Mechanical HVAC Module	3.1%	2.9%	86	89	87.5
*	Civil Environmental Depth Module	Mechanical Machine Design Module	3.4%	2.7%	84	91	87.5
*	Electrical Breadth Module	Mechanical HVAC Module	3.7%	1.7%	79	97	88
*	Civil Transportation Depth Module	Mechanical Machine Design Module	2.0%	4.1%	96	82	89
*	Electrical Breadth Module	Mechanical Machine Design Module	3.3%	1.9%	85	95	90
	Civil Geotechnical Depth Module	Industrial	1.5%	4.1%	102	82	92
*	Electrical Power Module	Mechanical Breadth Module	2.7%	2.0%	91	93	92
	Electrical Electronics Module	Industrial	1.7%	1.9%	101	94	97.5
*	Electrical ECC Depth Module	Mechanical HVAC Module	2.1%	1.4%	95	100	97.5
*	Electrical Power Module	Mechanical HVAC Module	1.9%	1.5%	99	98	98.5
*	Civil Geotechnical Depth Module	Mechanical Thermal and Fluids Systems Module	.9%	3.7%	113	85	99
*	Civil Structural Depth Module	Mechanical HVAC Module	2.0%	1.0%	98	102	100
	Civil Water Resources Depth Module	Manufacturing	2.3%	.7%	93	112	102.5
	Civil Transportation Depth Module	Manufacturing	1.2%	1.5%	107	99	103
	Electrical Computers Depth Module	Nuclear	1.8%	.8%	100	108	104
*	Electrical ECC Depth Module	Mechanical Thermal and Fluids Systems Module	4.3%	.1%	74	134	104
	Electrical Power Module	Chemical	1.2%	1.0%	107	103	105
*	Electrical ECC Depth Module	Mechanical Breadth Module	2.9%	.3%	87	123	105
*	Electrical Power Module	Mechanical Machine Design Module	1.3%	.6%	105	113	109

Table 10.6. (continued) Percent of Overlapping Content Among Practice and Title Discipline Exam Outlines (in Average Rank Order)

* Comparison Between Practice Act Disciplines	1st Discipline	2nd Discipline	Percent of 2nd Discipline's Exam Content Found on the 1st	Percent of 1st Discipline's Exam Content Found on the 2nd	Rank on 1st%	Rank on 2nd%	Average Rank Order
	Civil Structural Depth Module	Nuclear	.8%	.9%	116	104	110
*	Electrical Computers Depth Module	Mechanical HVAC Module	1.2%	.5%	106	115	110.5
	Electrical Electronics Module	Manufacturing	.7%	.9%	119	105	112
*	Civil Structural Depth Module	Electrical Computers Depth Module	.9%	.7%	113	111	112
*	Civil Transportation Depth Module	Electrical Breadth Module	.7%	.8%	120	106	113
*	Civil Structural Depth Module	Electrical Power Module	1.1%	.4%	110	117	113.5
	Civil Geotechnical Depth Module	Manufacturing	.4%	.8%	122	106	114
*	Electrical Computers Depth Module	Mechanical Breadth Module	.7%	.7%	118	110	114
*	Civil Water Resources Depth Module	Electrical Power Module	1.1%	.4%	110	120	115
	Civil Geotechnical Depth Module	Control Systems	.9%	.4%	115	116	115.5
*	Civil Environmental Depth Module	Electrical Power Module	1.1%	.3%	110	123	116.5
	Civil Structural Depth Module	Chemical	.3%	.7%	127	109	118
*	Electrical ECC Depth Module	Mechanical Machine Design Module	1.5%	.1%	103	134	118.5
	Civil Geotechnical Depth Module	Chemical	.3%	.6%	127	114	120.5
*	Civil Transportation Depth Module	Electrical Computers Depth Module	.4%	.4%	124	117	120.5
*	Civil Geotechnical Depth Module	Mechanical HVAC Module	.5%	.3%	121	122	121.5
*	Civil Structural Depth Module	Electrical Electronics Module	.3%	.4%	130	117	123.5
	Civil Water Resources Depth Module	Nuclear	.4%	.2%	122	127	124.5
*	Civil Water Resources Depth Module	Electrical Electronics Module	.3%	.4%	130	120	125
*	Electrical Computers Depth Module	Mechanical Thermal and Fluids Systems Module	.8%	.1%	117	133	125
*	Civil Environmental Depth Module	Electrical Electronics Module	.3%	.3%	130	123	126.5
*	Civil Transportation Depth Module	Electrical Electronics Module	.3%	.2%	126	127	126.5
*	Civil Breadth Module	Electrical Computers Depth Module	.3%	.3%	129	126	127.5
*	Electrical Computers Depth Module	Mechanical Machine Design Module	.3%	.2%	125	130	127.5
*	Civil Transportation Depth Module	Electrical Power Module	.1%	.2%	135	127	131
*	Civil Environmental Depth Module	Electrical Breadth Module	.2%	.2%	133	131	132
*	Civil Breadth Module	Electrical Breadth Module	.2%	.1%	133	132	132.5
	Civil Structural Depth Module	Control Systems	.0%	.0%	136	136	136
	Civil Geotechnical Depth Module	Nuclear	.0%	.0%	136	136	136
	Civil Transportation Depth Module	Nuclear	.0%	.0%	136	136	136
*	Civil Geotechnical Depth Module	Electrical Breadth Module	.0%	.0%	136	136	136
*	Civil Structural Depth Module	Electrical Breadth Module	.0%	.0%	136	136	136
*	Civil Water Resources Depth Module	Electrical Breadth Module	.0%	.0%	136	136	136
*	Civil Environmental Depth Module	Electrical Computers Depth Module	.0%	.0%	136	136	136
*	Civil Geotechnical Depth Module	Electrical Computers Depth Module	.0%	.0%	136	136	136
*	Civil Water Resources Depth Module	Electrical Computers Depth Module	.0%	.0%	136	136	136

Table 10.6. (continued) Percent of Overlapping Content Among Practice and Title Discipline Exam Outlines (in Average Rank Order)

* Comparison Between Practice Act Disciplines	1st Discipline	2nd Discipline	Percent of 2nd Discipline's Exam Content Found on the 1st	Percent of 1st Discipline's Exam Content Found on the 2nd	Rank on 1st%	Rank on 2nd%	Average Rank Order
*	Civil Breadth Module	Electrical Electronics Module	.0%	.0%	136	136	136
*	Civil Geotechnical Depth Module	Electrical Electronics Module	.0%	.0%	136	136	136
*	Civil Breadth Module	Electrical Power Module	.0%	.0%	136	136	136
*	Civil Geotechnical Depth Module	Electrical Power Module	.0%	.0%	136	136	136

Table 10.7. Number of Discipline Pairs with the Greatest Average Overlap in Exam Content

		Civil	Mechanical	Electrical & Computer	Total
Title Act Disciplines	Control Systems		3	2	5
	Chemical	2	4		6
	Industrial		1	3	4
	Nuclear		3	1	4
	Manufacturing		3		3
	Fire Protection	2	3		5
	Total	4	17	6	27
Practice Act Disciplines	Civil				
	Mechanical	3			
	Electrical & Computer				
	Total	3	0	0	30

Table 10.8 Percent of Title Act Discipline Exam Content Covered on Practice Act Discipline Exams

			Title Act Disciplines					
Practice Act Disciplines			Chemical	Control Systems	Fire Protection	Industrial	Manufacturing	Nuclear
Civil	Breadth Module		11.4%	6.1%	16.4%	4.9%	4.4%	5.6%
	Depth Modules	Environmental	20.9%	6.5%	16.1%	5.5%	3.8%	8.5%
		Geotechnical	.3%	.9%	4.0%	1.5%	.4%	.0%
		Structural	.3%	.0%	15.3%	3.6%	3.4%	.8%
		Transportation	2.8%	2.0%	13.4%	4.8%	1.2%	.0%
		Water Resources	13.1%	5.6%	14.3%	4.1%	2.3%	.4%
Electrical & Computer	Breadth Module		4.6%	9.8%	10.1%	9.6%	12.6%	6.2%
	Depth Modules	Computers	1.1%	12.3%	4.0%	6.0%	4.8%	1.8%
		Electronics, Controls, and Communication	1.3%	30.7%	5.3%	1.7%	.7%	7.5%
		Power	1.2%	5.0%	8.1%	5.9%	3.5%	2.2%
Mechanical	Breadth Module		33.7%	19.0%	17.5%	9.3%	16.7%	15.6%
	Depth Modules	HVAC and Refrigeration	39.7%	24.3%	26.9%	4.9%	5.9%	14.4%
		Machine Design	27.5%	10.4%	10.2%	14.0%	32.3%	11.0%
		Thermal and Fluids Systems	38.1%	16.9%	17.0%	8.7%	14.7%	13.9%

Table 10.9 Percent of Civil Exam Content Covered on Other Exams

			Civil Exams					
				Depth Modules				
			Breadth Module	Environmental	Geotechnical	Structural	Transportation	Water Resources
Electrical & Computer	Breadth Module		.13%	.16%	.00%	.00%	.83%	.00%
	Depth Modules	Computers	.28%	.00%	.00%	.69%	.41%	.00%
		Electronics, Controls, and Communication	.00%	.33%	.00%	.41%	.21%	.37%
		Power	.00%	.33%	.00%	.41%	.21%	.37%
Mechanical	Breadth Module		8.93%	3.40%	4.68%	17.57%	4.90%	7.35%
	Depth Modules	HVAC and Refrigeration	2.86%	3.00%	.34%	1.03%	3.30%	6.16%
		Machine Design	9.17%	2.72%	4.24%	20.54%	4.05%	5.77%
		Thermal and Fluids Systems	8.44%	4.08%	3.65%	15.72%	4.81%	8.54%
Title Act Disciplines	Chemical		10.60%	24.14%	.58%	.71%	4.28%	15.24%
	Control Systems		5.40%	5.52%	.42%	.00%	5.20%	13.13%
	Fire Protection		6.58%	5.47%	1.79%	10.70%	4.55%	10.18%
	Industrial		8.44%	15.41%	4.05%	5.13%	7.44%	5.62%
	Manufacturing		4.81%	9.88%	.83%	5.19%	1.47%	.68%
	Nuclear		2.75%	4.92%	.00%	.93%	.00%	.21%

Table 10.10 Percent of Electrical Exam Content Covered on Other Exams

			Electrical & Computer Exams			
				Depth Modules		
			Breadth Module	Computers	Electronics, Controls, and Communication	Power
Civil	Breadth Module		.22%	.27%	.00%	.00%
	Depth Modules	Environmental	.22%	.00%	.25%	1.07%
		Geotechnical	.00%	.00%	.00%	.00%
		Structural	.00%	.93%	.25%	1.07%
		Transportation	.67%	.39%	.31%	.11%
		Water Resources	.00%	.00%	.25%	1.07%
Mechanical	Breadth Module		10.46%	.70%	.33%	2.00%
	Depth Modules	HVAC and Refrigeration	1.66%	.49%	1.40%	1.48%
		Machine Design	1.85%	.18%	.07%	.59%
		Thermal and Fluids Systems	7.50%	.08%	.07%	5.73%
Title Act Disciplines	Chemical		11.94%	5.70%	7.15%	.96%
	Control Systems		11.47%	23.47%	21.73%	3.95%
	Fire Protection		8.58%	2.48%	1.33%	6.32%
	Industrial		17.31%	28.86%	1.91%	21.89%
	Manufacturing		11.00%	6.67%	.88%	8.89%
	Nuclear		11.54%	.80%	21.95%	4.64%

Table 10.11 Percent of Mechanical Exam Content Covered on Other Exams

			Mechanical Exams			
				Depth Modules		
			Breadth Module	HVAC and Refrigeration	Machine Design	Thermal and Fluids Systems
Civil	Breadth Module		13.56%	3.09%	14.88%	8.62%
	Depth Modules	Environmental	12.77%	5.84%	3.37%	14.28%
		Geotechnical	2.53%	.48%	4.57%	.93%
		Structural	11.09%	1.98%	21.74%	6.77%
		Transportation	5.73%	2.80%	2.00%	4.70%
		Water Resources	11.76%	4.79%	2.76%	12.93%
Electrical & Computer	Breadth Module		5.41%	3.68%	3.33%	3.67%
	Depth Modules	Computers	.73%	1.22%	.32%	.77%
		Electronics, Controls, and Communications	2.89%	2.12%	1.46%	4.31%
		Power	2.68%	1.85%	1.26%	4.57%
Title Act Disciplines	Chemical		33.97%	39.90%	10.77%	31.11%
	Control Systems		19.34%	18.96%	4.99%	20.59%
	Fire Protection		10.10%	6.63%	5.66%	9.28%
	Industrial		11.96%	13.49%	16.35%	15.31%
	Manufacturing		16.04%	5.49%	30.47%	13.07%
	Nuclear		15.12%	10.09%	6.56%	21.41%

Table 10.12. Overlap in California Licenses

Discipline	Total number of licensed engineers in discipline	Number of engineers in discipline who also have:			Percent of engineers in discipline who also have:		
		A civil engineering license	An electrical engineering license	A mechanical engineering license	A civil engineering license	An electrical engineering license	A mechanical engineering license
Civil	44,135	--	33	231	--	.1%	.5%
Electrical	8,444	33	--	144	.4%	--	1.7%
Mechanical	14,878	231	144	--	1.6%	1.0%	--
Agricultural	257	52	1	9	20.2%	.4%	3.5%
Chemical	2,012	22	3	61	1.1%	.1%	3.0%
Control Systems	2,324	19	167	111	.8%	7.2%	4.8%
Fire Protection	807	35	5	60	4.3%	.6%	7.4%
Industrial	845	8	2	28	.9%	.2%	3.3%
Manufacturing	1,340	1	2	23	.1%	.1%	1.7%
Metallurgical	423	1	1	16	.2%	.2%	3.8%
Nuclear	877	7	8	132	.8%	.9%	15.1%
Petroleum	473	5		7	1.1%		1.5%
Traffic	1,401	497	11	6	35.5%	.8%	.4%
Subtotal without civil	34,081	911	--	--	2.7%	--	--
Subtotal without electrical	69,772	--	377	--	--	.5%	--
Subtotal without mechanical	63,338	--	--	828	--	--	1.3%
Total	78,216	--	--	--	--	--	--

The initial data provided included current licenses issued up through January 25, 2002. It was later realized that this data inadvertently excluded chemical engineers, so data for chemical engineering licenses includes licenses issued up through June 26, 2002.

Engineers with more than one license were identified based on *exact* matches on both name and address information or exact matches on address information and two out of the three name components (first, middle, last). This second criteria was used to include individual whose name was recorded in a slightly different manner for one license than it was for another. The most common example of this is where one license shows a full middle name but the other shows just an initial.

Table 10.13. Sequence in which California Engineering Licenses were Issued, for those with a License in More than One Discipline

		Sequence for those with a civil engineering license and a license in another discipline				Sequence for those with an electrical engineering license and a license in another discipline				Sequence for those with a mechanical engineering license and a license in another discipline			
		Civil license issued:		Both issued at same time	Total	Electrical license issued:		Both issued at same time	Total	Mechanical license issued:		Both issued at same time	Total
	Other license	First	Second			First	Second			First	Second		
Percent	Civil	--	--	--	--	45.5%	54.5%		100.0%	45.5%	53.7%	.9%	100.0%
	Electrical	54.5%	45.5%		100.0%	--	--	--	--	42.4%	52.8%	4.9%	100.0%
	Mechanical	53.7%	45.5%	.9%	100.0%	52.8%	42.4%	4.9%	100.0%	--	--	--	--
	Agricultural	69.2%	30.8%		100.0%	100.0%			100.0%	44.4%	55.6%		100.0%
	Chemical	40.9%	59.1%		100.0%	66.7%	33.3%		100.0%	16.4%	83.6%		100.0%
	Control Systems	73.7%	26.3%		100.0%	75.4%	24.6%		100.0%	53.2%	46.8%		100.0%
	Fire Protection	97.1%	2.9%		100.0%	80.0%		20.0%	100.0%	76.7%	23.3%		100.0%
	Industrial	62.5%	37.5%		100.0%	100.0%			100.0%	75.0%	25.0%		100.0%
	Manufacturing	100.0%			100.0%	50.0%	50.0%		100.0%	43.5%	56.5%		100.0%
	Metallurgical		100.0%		100.0%	100.0%			100.0%	43.8%	56.3%		100.0%
	Nuclear	85.7%	14.3%		100.0%	100.0%			100.0%	56.8%	34.1%	9.1%	100.0%
	Petroleum	80.0%	20.0%		100.0%					85.7%	14.3%		100.0%
	Traffic	87.1%	12.5%	.4%	100.0%	81.8%	18.2%		100.0%	66.7%	33.3%		100.0%
	Total	75.1%	24.5%	.4%	100.0%	65.0%	32.9%	2.1%	100.0%	49.3%	48.2%	2.5%	100.0%
Number	Civil	--	--	--	--	15	18		33	105	124	2	231
	Electrical	18	15		33	--	--	--	--	61	76	7	144
	Mechanical	124	105	2	231	76	61	7	144	--	--	--	--
	Agricultural	36	16		52	1			1	4	5		9
	Chemical	9	13		22	2	1		3	10	51		61
	Control Systems	14	5		19	126	41		167	59	52		111
	Fire Protection	34	1		35	4		1	5	46	14		60
	Industrial	5	3		8	2			2	21	7		28
	Manufacturing	1			1	1	1		2	10	13		23
	Metallurgical		1		1	1			1	7	9		16
	Nuclear	6	1		7	8			8	75	45	12	132
	Petroleum	4	1		5					6	1		7
	Traffic	433	62	2	497	9	2		11	4	2		6
	Total	684	223	4	911	245	124	8	377	408	399	21	828

Table 10.14. Summary of Exams with More than Fifteen Percent Overlap in Content

Practice Act Discipline Exams	Module	Percent of :	Title Act Discipline Exams						Civil Engineering Exams	
			Chemical	Control Systems	Fire Protection	Industrial	Manufacturing	Nuclear	Breadth Module	Structural Module
Civil Engineering Exam	Environmental	Column exam content on row exam	21%			6%				
		Row exam content on column exam	24%			15%				
	Structural	Column exam content on row exam			15%					
		Row exam content on column exam			11%					
	Water Resources	Column exam content on row exam	13%							
		Row exam content on column exam	15%							
Electrical & Computer Engineering Exam	Breadth	Column exam content on row exam				10%				
		Row exam content on column exam				17%				
	Computers	Column exam content on row exam		12%		6%				
		Row exam content on column exam		24%		29%				
	Electronics, Controls and Communication	Column exam content on row exam		31%				8%		
		Row exam content on column exam		22%				22%		
	Power	Column exam content on row exam				6%				
		Row exam content on column exam				22%				
Mechanical Engineering Exam	Breadth	Column exam content on row exam	34%	19%	18%		17%	16%		18%
		Row exam content on column exam	34%	19%	10%		16%	15%		11%
	HVAC and Refrigeration	Column exam content on row exam	40%	24%						
		Row exam content on column exam	40%	19%						
	Machine Design	Column exam content on row exam	28%			14%	32%		19%	21%
		Row exam content on column exam	11%			16%	31%		15%	22%
	Thermal and Fluids Systems	Column exam content on row exam	38%	17%	17%	9%	15%	14%		16%
		Row exam content on column exam	31%	21%	9%	15%	13%	21%		7%

Exams with less than 15% overlap are not shown in this table (Geotechnical and Transportation Depth Modules of the Civil Engineering exam). The only overlap between Practice Act discipline exams was between civil and mechanical engineering.

Table 10.15. Percent of Experts Identifying Overlap Between Sections of the Chemical Engineering Exam and Exams with Noteworthy (15%+) Overlap

					Chemical Engineering Exam						
					(20%)	(15%)	(15%)	(10%)	(15%)	(10%)	(15%)
Exam	Module	% of Exam	Topic		Mass and Energy Balances	Heat Transfer	Fluids	Thermo-dynamics	Mass Transfer	Kinetics	Plant Design
Civil Engineering Exam (N=7)	Environmental Depth Module	(65%)	Environmental	Wastewater Treatment	29%		29%	43%	14%	14%	71%
				Biology							43%
				Solid/Hazardous Waste	29%	29%			14%		71%
				Ground Water and Well Fields							14%
		(10%)	Geotechnical	Subsurface Exploration and Sampling							
				Engineering Properties of Soils							
				Soil Mechanics Analysis							
		(25%)	Water Resources	Hydraulics	29%	14%	100%				14%
				Hydrology		29%					14%
				Water Treatment			14%				43%
	Water Resources Depth Module	(65%)	Water Resources	Hydraulics	29%	14%	100%				14%
				Hydrology		29%					14%
				Water Treatment			14%				43%
		(25%)	Environmental	Wastewater Treatment	14%		14%		14%		43%
				Biology							43%
				Ground Water and Well Fields							
		(10%)	Geotechnical	Subsurface Exploration and Sampling							
				Engineering Properties of Soils							
				Soil Mechanics Analysis							
Mechanical Engineering Exam (N=11)	Breadth Module	(15%)	General Knowledge, Codes & Standards	Engineering Principles	27%	91%	73%	27%	18%		36%
		(11%)		Fundamental Engineering Practice						9%	55%
		(4%)		Interpretation of Codes and Standards						18%	
		(11%)	Machine Design & Materials Knowledge	Principles							18%
		(6%)		Applications		9%					46%
		(9%)	Hydraulics & Fluids	Principles			36%				
		(8%)		Applications			27%				9%
		(10%)	Energy Conversion/Power Systems Knowledge	Principles	36%	27%		73%			9%
		(8%)		Analysis of Systems and Components	55%	18%	73%	18%	9%		9%
		(18%)	HVAC and Refrigeration Knowledge		9%	18%	9%	64%	18%		
	HVAC & Refrigeration Depth Module	(15%)	Fundamentals	Psychometrics				18%	64%		9%
		(19%)		Principles	55%	91%	82%	100%	27%		9%
		(37%)	Equipment and Materials		9%	64%	82%	73%	9%	9%	64%
		(21%)	Applications	Systems Applications		46%	46%	36%	18%		18%
		(8%)		Supportive Knowledges							46%
	Machine Design Depth Module	(43%)	Engineering Principles			9%	9%	9%		9%	46%
		(36%)	Components								
		(13%)	Applications	System Applications						18%	55%
		(8%)		Supportive Knowledges	55%	91%	73%	82%	27%		36%
	Thermal & Fluids Systems Depth Module	(22%)	Fundamentals	Engineering Principles	55%	91%	82%	91%	27%		55%
		(11%)		Supportive Knowledges		9%	9%	18%	18%		18%
		(14%)	Components	Hydraulic System Components			55%				9%
		(20%)		Power Plant Components	9%	73%	73%	9%	18%		9%
		(25%)	Applications	Systems Applications	18%	64%	73%	64%	18%	9%	9%
		(8%)		Application Supportive Knowledge						18%	

Percentages in parentheses in column and row headings indicate the percent of the exam that NCEES allocates to the topic.

Table 10.16. Percent of Experts Identifying Overlap Between Sections of the Control Systems Engineering Exam and Exams with Noteworthy (15%+) Overlap

					Control Systems Engineering Exam										
					(16%)	(6%)	(14%)	(6%)	(6%)	(6%)	(8%)	(18%)	(10%)	(8%)	(2%)
Exam	Module	% of Exam	Topic		Sensors	Analog & Digital Data Trans-mission	Valves & Final Elements	Process Dynamics	Control System Analysis	Controllers/ Modes/ Tuning	Digital Control Systems	Discrete Logic, Interlocks, Alarms and Se-quencing	Codes & Standards	Docu-mentation	Economics of Control
Electrical & Com-puter Engi-neering Exam (N=7)	Computers Depth Module	(4%)	General Computer Systems	Interpretation of Codes & Standards							14%		14%	14%	
		(6%)		Microprocessor Systems							29%				
		(16%)	Hardware	Digital Electronics							14%	43%		14%	
		(19%)		Design and Analysis							14%	29%		14%	
		(10%)		Systems							14%	14%		14%	
		(12%)	Software	System Software							43%				
		(23%)		Development/Applications							29%			43%	
		(10%)	Networks			57%									
	Electronics, Controls and Commu-nication Depth Module	(4%)	General Electrical Engineer-ing Know-ledge	Measurement & Instrumentation	57%										
		(2%)		Interpretation of Codes & Standards		14%						14%	57%	29%	
		(4%)		Computer Systems								29%			
		(10%)	Electronics	Electric Circuit Theory											
		(7%)		Electric and Magnetic Field Theory and Applications											
		(18%)		Electronic Components & Circuits								14%		14%	
		(10%)	Controls	Control System Fundamentals				29%	86%	14%	29%			14%	
		(6%)		Control System Design/Implementation				14%	57%	71%	43%				
		(9%)		Stability					71%	29%					
		(15%)	Commu-nications	Communication & Signal Processing		43%		14%							
		(8%)		Noise and Interface		14%									
		(7%)		Telecommunications		57%									

Percentages in parentheses in column and row headings indicate the percent of the exam that NCEES allocates to the topic

Table 10.16. (continued) Percent of Experts Identifying Overlap Between Sections of the Control Systems Engineering Exam and Exams with Noteworthy (15%+) Overlap

					Control Systems Engineering Exam										
					(16%)	(6%)	(14%)	(6%)	(6%)	(6%)	(8%)	(18%)	(10%)	(8%)	(2%)
Exam	Module	% of Exam	Topic		Sensors	Analog & Digital Data Trans-mission	Valves & Final Elements	Process Dynamics	Control System Analysis	Controllers/ Modes/ Tuning	Digital Control Systems	Discrete Logic, Interlocks, Alarms and Se-quencing	Codes & Standards	Docu-mentation	Economics of Control
Mech-anical Engineer-ing Exam (N=14)	Breadth Module	(15%)	General Know-ledge, Codes & Standards	Engineering Principles			79%	86%							
		(11%)		Fundamental Engineering Practice	21%	29%				7%		7%	29%	57%	79%
		(4%)		Interpretation of Codes & Standards								7%	50%		
		(11%)	Machine Design & Materials Knowledge	Principles											
		(6%)		Applications									7%		
		(9%)	Hydraulics & Fluids	Principles			29%	14%							
		(8%)		Applications											
		(10%)	Energy Conversion /Power Systems Knowledge	Principles				21%	7%						
		(8%)		Analysis of Systems & Components				57%							
		(18%)	HVAC & Refrigeration Knowledge				7%	21%							
	HVAC & Refrig-eration Depth Module	(15%)	Funda-mentals	Psychrometrics			7%	7%							
		(19%)		Principles			100%	100%	7%						
		(37%)	Equipment & Materials		57%	21%	36%	14%	29%	29%	14%	21%	7%		
		(21%)	Appli-cations	Systems Applications			21%	14%				7%	29%		
		(8%)		Supportive Knowledges			7%								79%
	Thermal & Fluids Systems Depth Module	(22%)	Funda-mentals	Engineering Principles			93%	100%	7%						79%
		(11%)		Supportive Knowledges			7%						7%		
		(14%)	Com-ponents	Hydraulic System Components	7%		14%	7%	14%	21%		7%			
		(20%)		Power Plant Components				21%							
		(25%)	Appli-cations	Systems Applications			21%	29%							
		(8%)		Application Supportive Knowledge								7%	50%		

Percentages in parentheses in column and row headings indicate the percent of the exam that NCEES allocates to the topic

Table 10.17. Percent of Experts Identifying Overlap Between Sections of the Fire Protection Engineering Exam and Exams with Noteworthy (15%+) Overlap

					Fire Protection Engineering Exam							
					(12%)	(13%)	(12%)	(13%)	(12%)	(13%)	(12%)	(13%)
					Planning and Design of:							
Exam	Module	% of Exam	Topic		Water Supplies	Building Systems	Water-Based Suppression Systems	Non Water-Based Suppression Systems	Detection and Alarm Systems	Fire Prevention	Imple-mentation & Monitoring of Fire Prevention	Research and Development of Hazard and Risk Analysis
Civil Engineering Exam (N=7)	Structural Depth Module	(65%)	Structural	Loadings								
				Analysis								
				Mechanics of Materials		14%						
				Materials		43%				14%		
				Member Design								
				Failure Analysis	14%	29%						14%
				Design Criteria	14%	57%	14%		14%	29%	14%	
		(25%)	Geotechnical	Subsurface Exploration and Sampling								
				Soil Mechanics Analysis								
				Shallow Foundations								
				Deep Foundations								
				Earth Retaining Structures								
		(10%)	Transportation	Construction	14%							
Mechanical Engineering Exam (N=13)	Breadth Module	(15%)	General Knowledge, Codes & Standards	Engineering Principles	8%	39%	8%	8%	8%	15%		8%
		(11%)		Fundamental Engineering Practice	15%	23%	31%	23%	23%	15%	15%	
		(4%)		Interpretation of Codes and Standards	8%	15%		8%				
		(11%)	Machine Design & Materials Knowledge	Principles		8%						
		(6%)		Applications		46%	8%	8%		15%	15%	
		(9%)	Hydraulics & Fluids	Principles								
		(8%)		Applications	15%						8%	
		(10%)	Energy Conversion/Power Systems Knowledge	Principles		8%					8%	8%
		(8%)		Analysis of Systems and Components		8%					8%	
		(18%)	HVAC and Refrigeration Knowledge									
	Thermal & Fluids Systems Depth Module	(22%)	Fundamentals	Engineering Principles	8%	46%	23%	8%	15%	15%	8%	8%
		(11%)		Supportive Knowledges		8%		8%			15%	
		(14%)	Components	Hydraulic System Components	15%						8%	
		(20%)		Power Plant Components		8%						
		(25%)	Applications	Systems Applications	31%	8%	15%	15%		8%	8%	
		(8%)		Application Supportive Knowledge	8%	15%		8%				

Percentages in parentheses in column and row headings indicate the percent of the exam that NCEES allocates to the topic

Table 10.18. Percent of Experts Identifying Overlap Between Sections of the Industrial Engineering Exam and Exams with Noteworthy (15%+) Overlap

					Industrial					
					(25%)	(25%)	(12%)	(13%)	(12%)	(13%)
Exam	Module	% of Exam	Topic		Facilities	Manu-facturing	Production & Inventory Systems	Work Systems	Quality Assurance	Manage-ment
Civil Engineering Exam (N=9)	Environmental Depth Module	(65%)	Environmental	Wastewater Treatment	33%					
				Biology	22%				33%	
				Solid/Hazardous Waste	56%			11%		
				Ground Water and Well Fields	11%				11%	
		(10%)	Geotechnical	Subsurface Exploration and Sampling	11%					
				Engineering Properties of Soils						
				Soil Mechanics Analysis						
		(25%)	Water Resources	Hydraulics						
				Hydrology	11%					
				Water Treatment	33%					
Electrical & Computer Engineering Exam (N=8)	Breadth Module	(6%)	Basic Electrical Engineering	Professionalism and Engineering Economics	13%	38%		13%		38%
		(6%)		Safety and Reliability				100%	88%	
		(24%)		Electric Circuits	13%					
		(3%)		Electric and Magnetic Field Theory and Applications						13%
		(6%)		Digital Logic						13%
		(14%)	Electronics, Electronic Circuits and Components	Components						
		(6%)		Electrical and Electronic Materials						
		(15%)	Controls and Communications Systems							
		(12%)	Power	Transmission and Distribution	50%					
		(8%)		Rotating Machines and Electromagnetic Devices	38%					
	Computers Depth Module	(4%)	General Computer Systems	Interpretation of Codes and Standards						38%
		(6%)		Microprocessor systems		13%				38%
		(16%)	Hardware	Digital Electronics						13%
		(19%)		Design and Analysis						13%
		(10%)		Systems						88%
		(12%)	Software	System Software						50%
		(23%)		Development/Applications		13%		13%	13%	38%
		(10%)	Networks							75%
	Power Depth Module	(5%)	General Power Engineering	Measurement, Instrumentation and Statistics	50%				38%	
		(2%)		Special Applications	38%					
		(8%)		Codes and Standards	25%				13%	
		(15%)	Circuit Analysis	Analysis						
		(8%)		Devices and Power Electronic Circuits	13%					
		(5%)		Electric and Magnetic Fields and Applications	13%					
		(18%)	Rotating Machines and Electromagnetic Devices	Rotating Machines	25%	13%				
		(9%)		Electromagnetic Devices	25%	13%				
		(15%)	Transmission and Distribution	System Analysis	50%					
		(6%)		Power System Performance	50%					
		(9%)		Protection	38%					
		(25%)	Applications	Systems Applications	39%					
		(8%)		Application Supportive Knowledge	8%				8%	

Percentages in parentheses in column and row headings indicate the percent of the exam that NCEES allocates to the topic

Table 10.18. (continued) Percent of Experts Identifying Overlap Between Sections of the Industrial Engineering Exam and Exams with Noteworthy (15%+) Overlap

					Industrial					
					(25%)	(25%)	(12%)	(13%)	(12%)	(13%)
Exam	Module	% of Exam	Topic		Facilities	Manu-facturing	Production & Inventory Systems	Work Systems	Quality Assurance	Manage-ment
Mechanical Engineering Exam (N=13)	Machine Design Depth Module	(43%)	Engineering Principles		31%	8%				
		(36%)	Components		15%					
		(13%)	Applications	Systems Applications	15%	46%		8%	8%	8%
		(18%)		Supportive Knowledges	23%	77%	31%		62%	23%
	Thermal & Fluids Systems Depth Module	(22%)	Fundamentals	Engineering Principles	23%	46%	31%	8%		23%
		(11%)		Supportive Knowledges	15%	8%		8%		
		(14%)	Components	Hydraulic System Components	15%					8%
		(20%)		Power Plant Components	23%					
		(25%)	Applications	Systems Applications	39%					
		(8%)		Application Supportive Knowledge	8%				8%	

Percentages in parentheses in column and row headings indicate the percent of the exam that NCEES allocates to the topic

Table 10.19. Percent of Experts Identifying Overlap Between Sections of the Manufacturing Engineering Exam and Exams with Noteworthy (15%)+ Overlap

					Manufacturing Engineering Exam									
					(6%)	(21%)	(9%)	(8%)	(6%)	(3%)	(17%)	(10%)	(15%)	(5%)
					Product Process Design, Materials Applications		Manufacturing Processes				Production Systems, Controls & Equipment Design			
Exam	Module	% of Exam	Topic		Materials Engineering & Applications	Product/ Process Design	Material Removal	Fabrication, Joining & Assembly	Forming	Finishing	Production, Systems & Control	Equipment Design	Quality	Manufacturing Management
Mechanical Engineering Exam (N=14)	Breadth Module	(15%)	General Knowledge, Codes & Standards	Engineering Principles	57%		7%		7%	7%				
		(11%)		Fundamental Engineering Practice	7%	79%					71%			100%
		(4%)		Interpretation of Codes and Standards		7%					7%	7%		
		(11%)	Machine Design & Materials Knowledge	Principles	43%	14%						21%		
		(6%)		Applications	57%	7%	7%	43%		7%		21%		
		(9%)	Hydraulics & Fluids	Principles	29%	21%								
		(8%)		Applications	14%									
		(10%)	Energy Conversion/Power Systems Knowledge	Principles										
		(8%)		Analysis of Systems and Components										
		(18%)	HVAC and Refrigeration Knowledge											
	Machine Design Depth Module	(43%)	Engineering Principles		64%	36%	7%		7%	7%		21%		
		(36%)	Components					43%				21%		
		(13%)	Applications	Systems applications		79%					64%	36%	7%	
		(8%)		Supportive Knowledges	43%	71%	14%	79%	36%	29%	29%	29%	71%	86%
	Thermal & Fluids Systems Depth Module	(22%)	Fundamentals	Engineering Principles	64%	79%	7%		7%	7%	64%			86%
		(11%)		Supportive Knowledges	43%	36%		43%				21%		
		(14%)	Components	Hydraulic System Components	14%									
		(20%)		Power Plant Components										
		(25%)	Applications	Systems Applications	14%	14%								
		(8%)		Application Supportive Knowledge		7%					7%	7%		

Percentages in parentheses in column and row headings indicate the percent of the exam that NCEES allocates to the topic

Table 10.20. Percent of Experts Identifying Overlap between Sections of the Nuclear Engineering Exam and Exams with Noteworthy (15%+) Overlap

					Nuclear Engineering Exam				
					(25%)	(20%)	(20%)	(20%)	(15%)
Exam	Module	% of Exam	Topic		Nuclear Power Systems	Nuclear Fuel and Waste Management	Nuclear Radiation Protection/ Radiation Shielding	Nuclear Criticality/ Kinetics/ Neutronics	Nuclear Measurements and Instruments
Electrical & Computer Engineering Exam (N=6)	Electronics, Controls and Commu-nication Depth Module	(4%)	General Electrical Engineering Knowledge	Measurement and Instrumentation					67%
		(2%)		Interpretation of Codes and Standards					17%
		(2%)		Computer Systems					17%
		(10%)	Electronics	Electric Circuit Theory					17%
		(7%)		Electric and Magnetic Field Theory and Applications					
		(18%)		Electronic Components and Circuits					33%
		(10%)	Controls	Control System Fundamentals					50%
		(6%)		Control System Design/Implementation					83%
		(9%)		Stability					33%
		(15%)	Communications	Communication and Signal Processing					
		(8%)		Noise and Interface					17%
		(7%)		Telecommunications					
Mechanical Engineering Exam (N=15)	Breadth Module	(15%)	General Knowledge, Codes & Standards	Engineering Principles	53%	13%			
		(11%)		Fundamental Engineering Practice	7%	60%	47%		27%
		(4%)		Interpretation of Codes and Standards	7%		7%		
		(11%)	Machine Design & Materials Knowledge	Principles	7%				
		(6%)		Applications	20%	7%			
		(9%)	Hydraulics & Fluids	Principles	27%				
		(8%)		Applications	20%				
		(10%)	Energy Conversion/ Power Systems Knowledge	Principles	33%				
		(8%)		Analysis of Systems and Components	60%				
		(18%)	HVAC and Refrigeration Knowledge						
	Thermal & Fluids Systems Depth Module	(22%)	Fundamentals	Engineering Principles	93%	60%			
		(11%)		Supportive Knowledges	20%				
		(14%)	Components	Hydraulic System Components	20%				
		(20%)		Power Plant Components	67%				
		(25%)	Applications	Systems Applications	53%				
		(8%)		Application Supportive Knowledge	7%		7%		

Percentages in parentheses in column and row headings indicate the percent of the exam that NCEES allocates to the topic

Table 10.21. Percent of Experts Identifying Overlap Between Sections of the Machine Design Depth Module of the Mechanical Engineering Exam and Exams with Noteworthy (15%+) Overlap

					Machine Design Depth Module of Mechanical Engineering Exam			
					(43%)	(36%)	(13%)	(18%)
							Applications	
Exam	Module	% of Exam	Topic		Engineering Principles	Components	Systems applications	Supportive Knowledges
Civil Engineering Exam (N=14)	Breadth Module	(20%)	Environmental					7%
		(20%)	Geotechnical		7%			
		(20%)	Structural		71%	7%	50%	14%
		(20%)	Transportation					29%
		(20%)	Water Resources		29%			71%
	Structural Depth Module	(65%)	Structural	Loadings	43%		7%	
				Analysis	21%		36%	
				Mechanics of Materials	50%	14%	21%	
				Materials	7%			14%
				Member Design	14%	7%		
				Failure Analysis	64%		21%	
				Design Criteria			29%	
		(25%)	Geotechnical	Subsurface Exploration and Sampling				
				Soil Mechanics Analysis	7%			
				Shallow Foundations				
				Deep Foundations				
				Earth Retaining Structures				
		(10%)	Transportation	Construction				29%

Percentages in parentheses in column and row headings indicate the percent of the exam that NCEES allocates to the topic

Table 10.22. Percent of Experts Identifying Overlap Between Sections of the Structural Depth Module of Civil Engineering Exam and Exams with Noteworthy (15%+) Overlap

					Structural Depth Module of Civil Engineering Exam												
					(65%)							(25%)					(10)
					Structural							Geotechnical					Trans-portation
Exam	Module	% of Exam	Topic		Loadings	Analysis	Mech-anics of Materials	Materials	Member Design	Failure Analysis	Design Criteria	Sub-surface Explor-ation & Sampling	Soil Mech-anics Analysis	Shallow Foun-dations	Deep Foun-dations	Earth Retain-ing Struc-tures	Con-struction
Mechanical Engineering Exam (N=14)	Breadth Module	(15%)	General Knowledge, Codes & Standards	Engineering Principles			14%						7%				
		(11%)		Fundamental Engineering Practice							14%						29%
		(4%)		Interpretation of Codes and Standards							29%						
		(11%)	Machine Design & Materials Knowledge	Principles	43%	21%	50%	7%	14%	64%							
		(6%)		Applications	36%		7%	14%		14%				7%			
		(9%)	Hydraulics & Fluids	Principles													
		(8%)		Applications													
		(10%)	Energy Conversion/ Power Systems Knowledge	Principles													
		(8%)		Analysis of Systems and Components													
		(18%)	HVAC and Refrigeration Knowledge														
	Thermal & Fluids Systems Depth Module	(22%)	Fundamentals	Engineering Principles			14%						7%				29%
		(11%)		Supportive Knowledges	43%	21%	50%	21%	14%	71%							
		(14%)	Components	Hydraulic System Components													
		(20%)		Power Plant Components													
		(25%)	Applications	Systems Applications													
		(8%)		Application Supportive Knowledge							2%						

Percentages in parentheses in column and row headings indicate the percent of the exam that NCEES allocates to the topic